Alaska Asphalt Pavement Summit
Dec. 4, 2007 Anchorage, AK

What is Warm Mix Asphalt?
- Hot Mix Asphalt 275-325°F
- Warm Mix Asphalt 220-275°F
- Half-Warm Mix Asphalt 180-220°F
- Cold Mix Asphalt 60°F

Why the interest?
- Lower temperatures for production and lay down
- Reduce emissions
- Reduce energy costs
- Reduce oxidation of binder
- Other Possible Benefits:
  - Cool weather paving (extend season)
  - Compaction aid for stiff mixes
**Construction Advantages**

- Haul material longer distances
  - Possible increase in plant coverage area
- Increased workability
  - Easier to compact and obtain density
- Decreased oxidation of binders during production
- Construction in colder weather

**Emission Exposure**

<table>
<thead>
<tr>
<th>Employee</th>
<th>Conventional Asphalt 160-180°C</th>
<th>Low Temperature Asphalt approx. 130°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paver Operator</td>
<td>6.5 mg/m³</td>
<td>0.4-3.1 mg/m³</td>
</tr>
</tbody>
</table>
| Screed Operator  | 10.4 mg/m³                    | 0.6-6.9 mg/m³                         


<table>
<thead>
<tr>
<th>Process</th>
<th>Temperature</th>
<th>Equivalent °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Mix (155 °C)</td>
<td>311 °F</td>
<td></td>
</tr>
<tr>
<td>WAM (110 °C)</td>
<td>230 °F</td>
<td></td>
</tr>
</tbody>
</table>
Do Emissions Really Matter?

- Debate about asphalt fumes being carcinogenic since 1977
- NAPA objected to initial studies based on roofing materials
  - Roofing materials have a higher temperature than road asphalt
- 1990 Clean Air Act will significantly restrict air pollutions
- 2005 Clean Air Interstate Rule cleaner air by 2015

Do Emissions Really Matter? (cont’d)

- OSHA is still researching the affects of asphalt fumes on workers
  - Decision could change how asphalt is produced
  - WMA seen as possible alternative
- Pollution reduction acts have created non-attainment areas
  - Already require very strict air pollution control
  - WMA being used in some of these areas
  - Allows for greater haul distances
  - Plants not in non-attainment areas

Current Non-Attainment Areas
Brief History

- 1997 German Bitumen Forum
- 2000 Second Euroasphalt & Eurobitume Congress (Barcelona)
- NAPA 2002 European Scan Tour — Germany and Norway
- NAPA 2003 Annual Convention — San Diego
- World of Asphalt 2004
- 2005-2006 – Numerous U.S. Field Trials
- 2007 – FHWA/AASHTO Scan Tour

Goals for Warm Mix Asphalt

- Use existing Hot Mix Asphalt plants
- To meet existing standards for Hot Mix Asphalt specifications
- Focus on dense graded mixes for wearing courses
- WMA quality = Hot Mix Asphalt quality
**WAM-Foam**

- Two Phase addition of asphalt
- Aggregate coated with “soft” asphalt
- Hard asphalt foamed to mix with pre-coated aggregate
- Soft asphalt controls minimum placement temperature
- Material placed as low as 80°C (176°F), 50 – 60°C (90 – 108°F) reduction
- Requires plant modification for foaming, estimated at $50,000 - $70,000. No additional costs thereafter
- Special asphalt feeds may be required

**Zeolite**

- Zeolites are crystalline hydrated aluminum silicates
- When the Zeolite is heated, it gives up its internal moisture, approximately 21% by weight, microscopically foaming the asphalt
- Approximately 6 lbs Advera® WMA or Asphamin® per ton
- Added where fiber would be added

**Granulated Zeolite**
Sasobit®/Sasoflex

- Fischer-Tropsch synthetic waxes – Sasobit
  - Produced from gasification of coal or natural gas feed stocks
  - Added to binder or directly into mix
  - Can incorporate an SBS modifier using special cross-linking agent (Sasoflex)
  - Does not require high-shear blending
  - May negatively impact low temperature properties

Evotherm®

- Emulsion – approximately 70% binder residue
- Chemical package provides mixing, coating, workability, compaction and adhesion (e.g. anti-stripping agents)
- Some steam liberated upon mixing
Evotherm® DAT
- Liquid added to binder
- Generally 80% binder 20% liquid
- Latest WMA technology from MeadWestvaco

Evotherm® North American Field Trials
- 2005-2006
  - San Antonio
  - Indiana
  - Ontario
  - California
  - NCAT Test Track

Low Energy Asphalt (L.E.A)
- Hot Asphalt: 140 to 180 °C
- Hot coarse aggregates: 145 °C
- Cold & wet fine aggregates
- Final mix temperature < 100 °C

Courtesy of Fairco
L.E.A's Sequential Mixing

PHASE 1
- Dry, coarse aggregates
- Coarse aggregates are coated by asphalt

PHASE 2
- Moisture from fine aggregates triggers asphalt foaming
- Foamed asphalt encapsulates fine aggregates

PHASE 3
- Thermal equilibrium reached
- All aggregates uniformly coated

120°/150°C
170°C
100°C
90°C

PHASE 4
PHASE 5

PHASE 1
PHASE 2
PHASE 3
PHASE 4
PHASE 5

Courtesy of Fairco

EZ Asphalt

- Foaming Technology
  - Asphalt
  - Cold Water
  - Air
  - Temp ~ 250 – 270°F

Astec® Green Asphalt

- Foamed asphalt via nozzle head
- Air and water shot into binder
  - Moisture added is 0.1% by wt of total mix
- Mixing temperatures have ranged between 245-275°F
Other Technologies

- SuBit (Licomont): Montanwax
- Temp drop similar to Sasobit
- Colas
- 2-Phase Process
- Polyolefins
- BAM – Low Energy Asphalt Concrete
- Foam Process
- 195°F

Applications

- Dense-graded mixes
  - Majority of projects
  - RAP – Wisconsin and Missouri
- SMA
  - Maryland – Washington Beltway
- Open-graded mixes
  - Florida
  - China
- Asphalt-Rubber
  - California

Reduced Emissions

- Aspha-min – North Carolina – 265°F
  - 17.6% decrease in SO₂
  - 3.2% decrease in CO₂
  - 35.3% decrease in total hydrocarbons
  - 4.1% decrease in NOₓ
- Evotherm – Canada – 140°F
  - 45.8% decrease in CO₂
  - 63.1% decrease in CO
  - 41.2% decrease in SO₂
  - 58% decrease in NOₓ
- Direct comparisons are discouraged – different plants, different weather, different temperatures

Data provided by suppliers.
What Have We Learned?

- WMA additives improve lab and field compaction.
- In the lab, rutting increases with lower temperatures – may not translate to the field.
- Moisture, trapped in the aggregates and introduced into the mix, still a concern. Can mitigate effect in lab.
- NEED TO ADJUST BURNER FOR LOWER TEMPERATURE!
- Need best practices for aggregate moisture.
- Need best paving practices.

Things We Need to Go Forward

- Larger trials – Yellowstone and Texas – 30 k tons
- A robust product evaluation protocol
- WE NEED A PERFORMANCE TEST!
- Better understanding of effect on rutting and moisture damage
- Procedures for mix design and QC/QA (Do they need to be different?)
- A way for Agencies to specify
  - Temperature reduction?
  - Binder grade?